(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 353 632 A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 89113874.5

(51) Int. Cl.4: H01J 1/32

BR

(22) Date of filing: 27.07.89

(30) Priority: 04.08.88 IL 87341

(43) Date of publication of application:
07.02.90 Bulletin 90/06

(84) Designated Contracting States:
AT BE CH DE ES FR GB GR IT LI LU NL SE

(71) Applicant: YEDA RESEARCH AND DEVELOPMENT COMPANY, LTD.
Weizmann Institute of Science Herzl Street
at Yavne Road P.O. Box 95
Rehovot 76100(IL)

(72) Inventor: Vager, Zeev
18 Neve Metz The Weizmann Institute of Science
Rehovot(IL)
Inventor: Naaman, Ron
14 Tel Aviv Street
Ness Ziona(IL)

(74) Representative: Kraus, Walter, Dr. et al
Patentanwälte Kraus, Weisert & Partner
Thomas-Wimmer-Ring 15
D-8000 München 22(DE)

(54) Amorphous electron multiplier.

(57) An electron multiplier including a multi-layer arrangement of material which provides secondary electron emissions when impinged upon by electrons and apparatus for applying an electric field across the material. A cathode ray tube, and devices incorporating a cathode ray tube, such as televisions and oscilloscopes are also provided in accordance with the invention.

EP 0 353 632 A2

FIELD OF THE INVENTION

The present invention relates to detectors of radiation, atoms, molecules and charged species generally, and more particularly to electron multipliers and devices employing same.

BACKGROUND OF THE INVENTION

Various types of detectors are known for radiation and charged species. Discrete dynode multipliers have been employed for detection of electrons, ions and short wavelength radiation such as X-ray and Vacuum Ultraviolet radiation. Dynode multipliers operate by emitting secondary electrons upon impingement of a high energy beam upon a first dynode. The secondary electrons are accelerated by an electric field so that they collide with a further dynode, which again emits a few secondary electrons for each impinging electron. This process continues for multiple dynodes, thus producing electron amplification.

More recently, single channel electron multipliers have been developed, as described, for example in "Channel Electron Multipliers", Acta Electronica, Vol. 14, No. 1, 2 (1971). Such electron multipliers comprise a hollow glass tube, about 1 mm in diameter, having an internal resistive surface which has a high secondary electron emission coefficient. The electron multiplier is operated under vacuum and a potential difference is applied across electrodes at the ends of the tube. When an electron or other charged particle or photon enters the low potential end of the tube and collides with the tube wall, several secondary electrons are produced. The secondary electrons are accelerated by the applied axial electrical field and undergo further collisions with the wall and thus produce more secondary electrons. This process is repeated many times along the channel, producing a large number of electrons.

A channel plate electron multiplier or microchannel plate (MCP) may be formed of a parallel array of straight single-channel multipliers and produces a useful gain of about 10^6, which is limited by ionic feedback, whereas single channel electron multipliers achieve a gain of up to 10^8. Such microchannel plates are described, for example, in U.S. Patents 4,714,861 and 4,568,853.

In order to achieve a comparable gain with an MCP, two plates may be operated in cascade or a single sandwich plate can be provided by fusing two or more separate plates into a single unit.

Microchannel plates have limited usefulness due to relatively low production yields and consequently high cost, as well as limited efficiency.

SUMMARY OF THE INVENTION

The present invention seeks to provide an improved electron multiplier which avoids the limitations of the prior art, and due to its high efficiency and low cost may find application in mass produced products which currently employ cathode ray tubes, such as televisions.

There is thus provided in accordance with a preferred embodiment of the invention, an electron multiplier comprising a multi-layer arrangement of material which provides secondary electron emissions when impinged upon by electrons and apparatus for applying an electric field across the material.

According to a preferred embodiment of the invention, the multi-layer arrangement of material comprises a collection of beads of glass and means for applying an electric field across the layer.

Preferably the multi-layer arrangement comprises an amorphous arrangement of material.

In addition to glass beads, the material may alternatively comprise any suitable material which provides secondary electron emission in response to impingement of electrons thereon. Examples of such materials are: plastic particles at least partially coated with a metal, porous materials, such as lava rock, at least partially coated with a metal, particulate metal or metal ores. Preferably the materials are in relatively small particles, of maximum dimensions 1 - 1000 microns. Alternatively, the material may be a non-particulate material, such as a highly porous material.

For the example of glass beads, the thickness of the collection is at least five bead diameters and may be as great as about one centimeter. A preferred range of thickness of the collection is 5 - 50 bead diameters.

Similar parameters apply to other suitable materials.

Preferably, the surface conductivity of the material is of the order of tens to hundreds of megaohms.

A preferable glass is metal doped glass. A standard doped glass such as Corning 8161 glass is preferred. This glass has a high concentration of

lead oxide, typically 54.9% by weight.

Preferably, the structure of the collection is maintained by sintering the glass beads or the other materials in a planar array.

The invention also includes an active amplifier comprising a collection of beads of glass and means for applying an electric field across the collection of beads, in accordance with an embodiment of the present invention.

The invention further includes a novel cathode ray tube comprising an electron emitter, an electron multiplier as described above, arranged to receive electrons from the emitter and a phosphor screen arranged to be illuminated by the secondary electron emission from the electron multiplier.

The invention also includes relatively inexpensive, light weight and low radiation emissive devices, such as televisions, oscilloscopes, computer displays and night vision apparatus employing a cathode ray tube as described above.

The electron multiplier of the present invention is operative in response to impinging X-ray radiation and is thus suitable for use in X-ray imaging.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description, taken in conjunction with the drawings in which:

Fig. 1 is a side view sectional illustration of an electron multiplier constructed and operative in accordance with a preferred embodiment of the present invention;

Fig. 2 is a side view sectional illustration of an electron multiplier of the type shown in Fig. 1 and including additional electrodes;

Fig. 3 is a partial top view illustration of the electron multiplier of Figs. 1 and 2;

Fig. 4 is a sectional illustration of part of a spherical detector constructed and operative in accordance with a preferred embodiment of the present invention;

Fig. 5 is a simplified sectional illustration of a cathode ray tube constructed and operative in accordance with a preferred embodiment of the present invention;

Fig. 6 is a simplified sectional illustration of a television constructed and operative in accordance with a preferred embodiment of the present invention; and

Fig. 7 is a simplified sectional illustration of an oscilloscope constructed and operative in accordance with a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Reference is now made to Figs. 1 and 3, which illustrate an electron multiplier constructed and operative in accordance with a preferred embodiment of the present invention.

In accordance with a preferred embodiment of the invention, the electron multiplier comprises a multi-layer arrangement of material which provides secondary electron emissions when impinged upon by electrons and apparatus for applying an electric field across the material.

Preferably the multi-layer arrangement comprises an amorphous arrangement of material.

In the illustrated example, the electron multiplier comprises a three-dimensional amorphous collection 10 of glass beads 12 arranged between first and second electrodes 14 and 16, typically polarized as shown.

In addition to glass beads, the material may alternatively comprise any suitable material or materials which provides secondary electron emission in response to impingement of electrons thereon. Examples of such materials are: plastic particles at least partially coated with a metal, porous materials, such as lava rock, at least partially coated with a metal, particulate metal or metal ores. Preferably the materials are in relatively small particles, of maximum dimensions 1 - 1000 microns.

As seen in Fig. 3 the electrodes 14 and 16 are typically grids. It is to be appreciated that the beads are not normally arranged in a regular array as illustrated for simplicity. The electrodes may be sintered onto the collection 10 of materials or alternatively coated or otherwise attached thereto.

Application of suitable voltages across the electrodes 14 and 16, such as a potential difference of 20 - 40 Volts per bead diameter, produces an electric field across the electron multiplier. As illustrated schematically, but not to scale, electrons enter the electron multiplier adjacent electrode 14 and are accelerated by the electric field to produce multiple collisions with the surfaces of the beads 12, thus producing multiple stage emissions of secondary electrons.

It will be appreciated that the ratio between the number of electrons received and emitted by the electron multiplier in Fig. 1 is not representative and merely illustrates that the number increases. In fact the multiplication ratio may be approximately a factor of 2 - 3 per collision, for a total amplification of 10^3 - 10^8.

Preferably, the diameter of the beads 12 is within the range of 1 to 1000 microns. The thickness of the collection 10 is at least five bead diameters and may be as great as about one centimeter. A preferred range of thickness of the

collection is 5 - 30 bead diameters.

The beads are preferably solid and generally spherical.

Preferably, the surface conductivity of the material is of the order of tens to hundreds of megaohms.

A preferable glass for the beads is metal doped glass. A standard doped glass such as Corning 8161 glass. Where glass beads are employed, the metal content of the glass should be at least 15% by volume. The electrodes can be made of any suitable material, such as nickel or chrome plated metal.

Preferably, the structure of the collection is maintained by sintering the glass beads in a planar array.

Reference is now made to Fig. 2, which illustrates an electron multiplier similar to that of Fig. 1 but also including additional electrodes 18 and 20. These electrodes can have a selected voltage applied thereto and thereacross so as to provide desired control and enhancement of electron multiplication.

It will be appreciated that the electron multiplier of the present invention may extend over a relatively large area and need not be planar. Fig. 4 illustrates part of a spherical electron multiplier which may be produced in accordance with a preferred embodiment of the invention.

The invention also includes an active amplifier comprising a collection of beads of glass and means for applying an electric field across the collection of beads, in accordance with an embodiment of the present invention.

The invention further includes a novel cathode ray tube as illustrated in Fig. 5 and comprising an electron emitter 30, an electron multiplier 32 as described in any of the above examples, arranged to receive electrons from the emitter 30 and a phosphor screen 34 arranged to be illuminated by the secondary electron emission from the electron multiplier.

The invention also includes relatively inexpensive, light weight and low radiation emissive devices, such as televisions, oscilloscopes, computer displays and night vision apparatus employing a cathode ray tube as described above.

Fig. 6 illustrates a television comprising a housing 40, controls 42 and receiver circuitry 44, which may be entirely conventional. A thin profile cathode ray tube 46 of the type illustrated in Fig. 5 provides a display of high intensity.

Fig. 7 illustrates an oscilloscope comprising a housing 50, controls 52 and driver circuitry 54, which may be entirely conventional. A high intensity cathode ray tube 46 of the type illustrated in Fig. 5 provides a display which is responsive to short duration signals.

It will be appreciated that the electron multiplier of the present invention is operative in response to impinging X-ray radiation and is thus suitable for use in X-ray imaging.

It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described hereinabove. Rather the scope of the present invention is defined only by the claims which follow:

Claims

1. An electron multiplier comprising:
a multi-layer arrangement of material which provides secondary electron emissions when impinged upon by electrons; and
means for applying an electric field across the material.

2. An electron multiplier according to claim 1 and wherein said multi-layer arrangement of material comprises a collection of beads of glass.

3. An electron multiplier according to either of claims 1 and 2 and wherein said multi-layer arrangement comprises an amorphous arrangement of material.

4. An electron multiplier according to any of claims 1 - 3 and wherein said means for applying comprises electrode means.

5. An electron multiplier according to claim 4 and wherein said multi-layer arrangement is sintered onto the electrode means.

6. An electron multiplier according to claim 2 and wherein said collection of beads is amorphously packed.

7. An electron multiplier according to any of the preceding claims and wherein the material is in particulate form having a maximum dimension within the range of 1 to 1000 microns.

8. An electron multiplier according to any of the preceding claims and wherein the thickness of the arrangement is at least five particle diameters and up to approximately one centimeter.

9. An electron multiplier according to claim 2 and wherein the thickness of the collection is in the range of 5 - 30 bead diameters.

10. An electron multiplier according to any of the preceding claims and wherein the material comprises solid and generally spherical particles.

11. An electron multiplier according to any of the preceding claims and wherein said material has a surface conductivity of the order of tens to hundreds of megaohms.

12. An electron multiplier according to any of the preceding claims and wherein the material comprises beads formed of metal doped glass.

13. A non-planar electron multiplier comprising a multi-layer arrangement of material which pro-

vides secondary electron emissions when impinged upon by electrons and means for applying an electric field across the collection of beads.

14. A spherical detector comprising a multi-layer arrangement of material which provides secondary electron emissions when impinged upon by electrons and means for applying an electric field across the arrangement of material.

15. An active amplifier comprising a multi-layer arrangement of material which provides secondary electron emissions when impinged upon by electrons and means for applying an electric field across the arrangement of material.

16. A cathode ray tube comprising:
an electron emitter;
an electron multiplier arranged to receive electrons from the emitter and comprising a multi-layer arrangement of material which provides secondary electron emissions when impinged upon by electrons and means for applying an electric field across the arrangement of material; and
a phosphor screen arranged to be illuminated by the secondary electron emission from the electron multiplier.

17. A television comprising:
television signal receiving circuitry;
an electron emitter operative to provide electron emission in accordance with a received television signal;

an electron multiplier arranged to receive electrons from the emitter and comprising a multi-layer arrangement of material which provides secondary electron emissions when impinged upon by electrons and means for applying an electric field across the arrangement of material; and
a phosphor screen arranged to be illuminated by the secondary electron emission from the electron multiplier.

18. An oscilloscope comprising:
signal generating circuitry;
an electron emitter operative to provide electron emission in accordance with a signal generated by said signal generating circuitry;
an electron multiplier arranged to receive electrons from the emitter and comprising a multi-layer arrangement of material which provides secondary electron emissions when impinged upon by electrons and means for applying an electric field across the arrangement of material; and
a phosphor screen arranged to be illuminated by the secondary electron emission from the electron multiplier.

19. An electron multiplier comprising a multi-layer arrangement of material which provides secondary electron emissions when impinged upon by X-rays and means for applying an electric field across the arrangement of material.

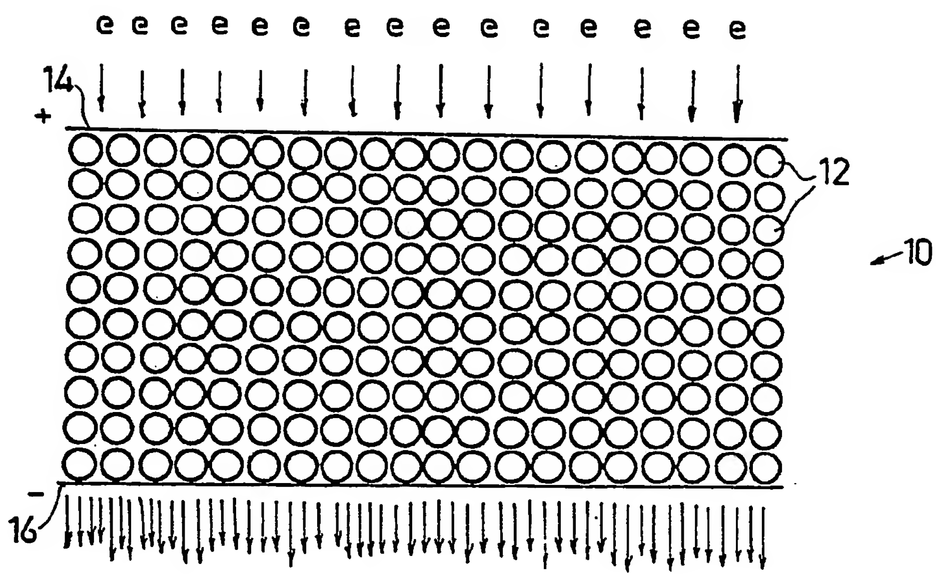

FIG.1

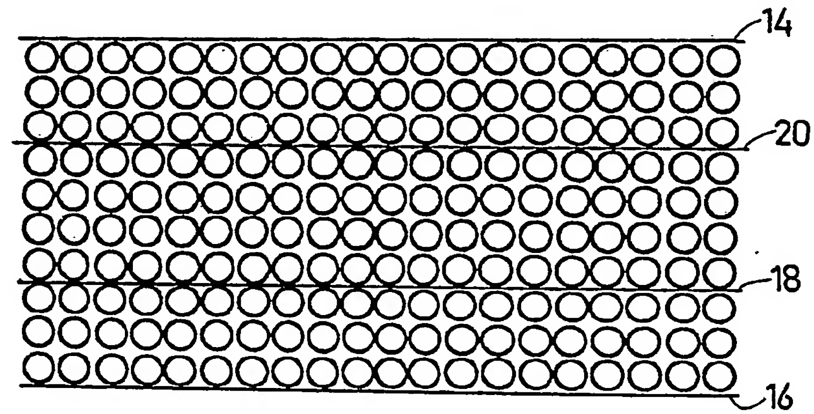

FIG.2

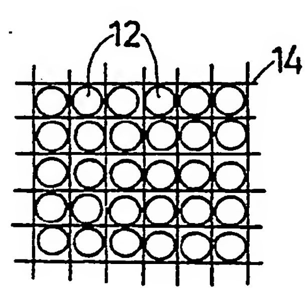

FIG.3

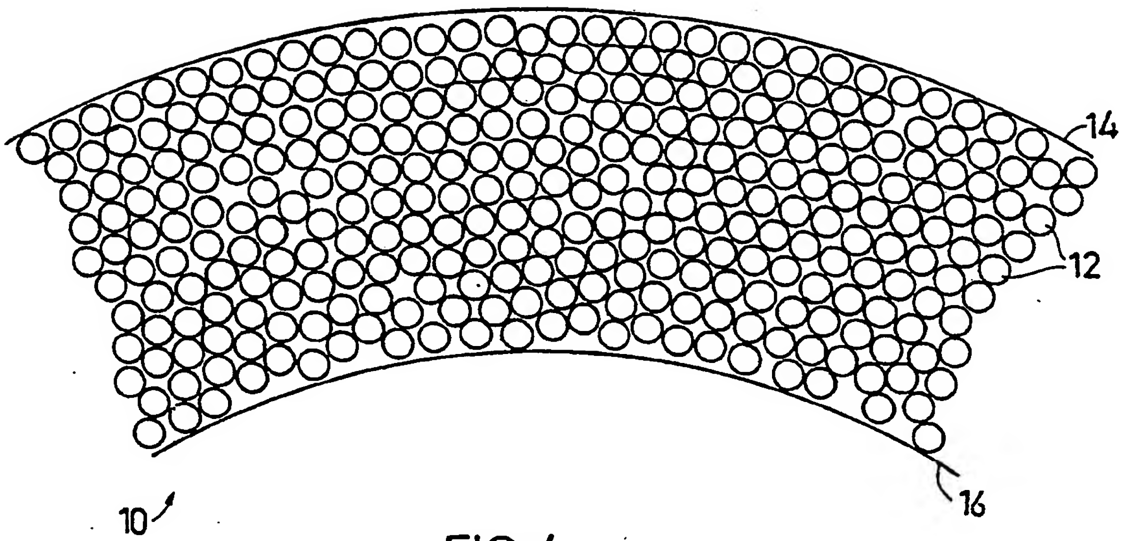

FIG.4

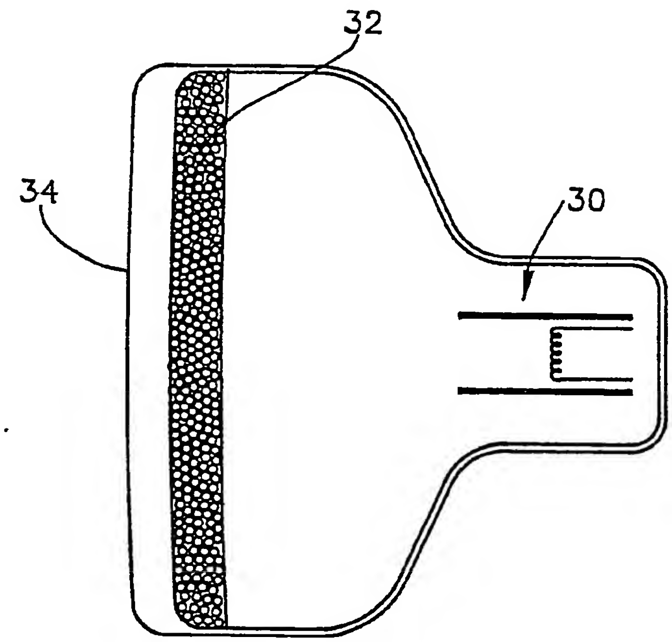

FIG.5

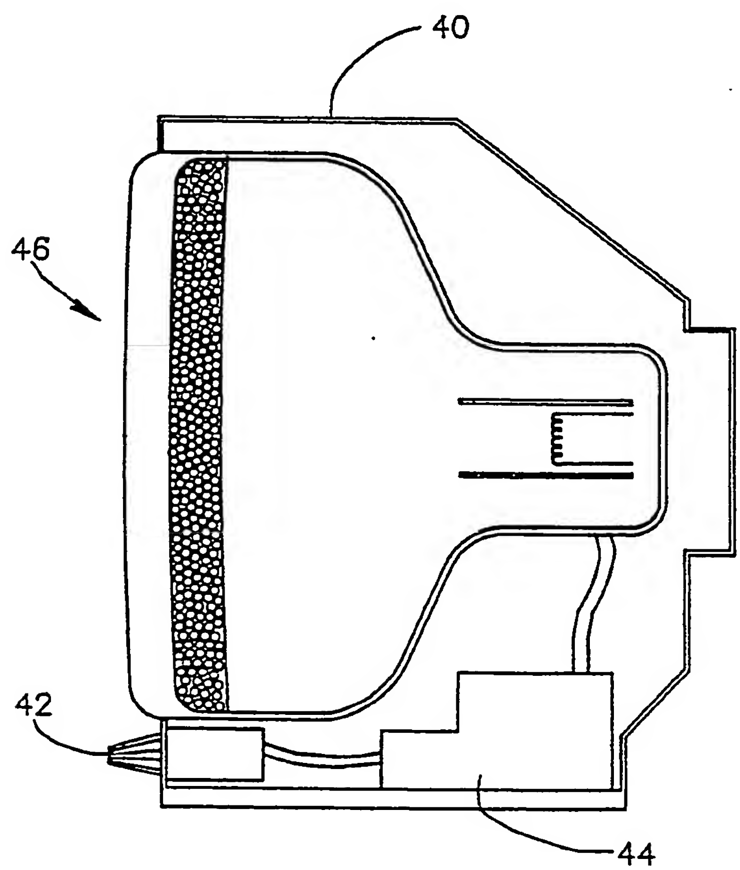

FIG.6

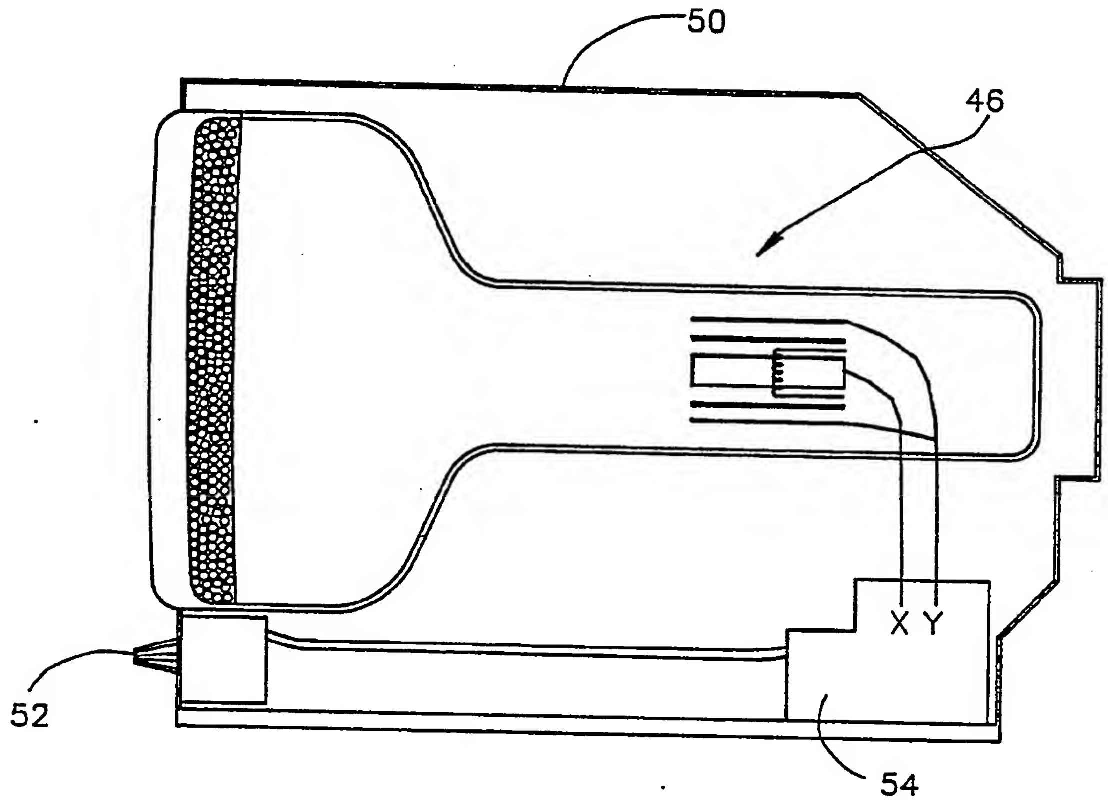

FIG.7